



EEG Paradigms

Course Instructor

Dr. Annushree Bablani

Acknowledgments: Dr Sreeja SR

Direct (noninvasive) interfaces in EEG

- An event-related potential (ERP) is any measured brain response that is directly the result of a thought or perception. More formally, it is any stereotyped electrophysiological response to an internal or external stimulus.
- Direct Interfaces via EEG
 - VEP – Visual Evoked Potential
 - AEP – Auditory Evoked Potential
 - SSVEP – Steady-State Visual Evoked Potential
 - P300 – ERP elicited by infrequent, task-relevant stimuli.
 - ERS/ERD – Event related synchronization/desynchronization
 - SCP – Slow cortical potentials

Categorization of EEG based BCI paradigms

Evoked (Endogenous / Asynchronous)




- Subject must pay attention for a certain time to external cues (e.g. flashes, sounds, etc.)
- Cue-based

Spontaneous (Exogenous / Synchronous)

- No continuous attention to specific stimulus is necessary
- User-driven



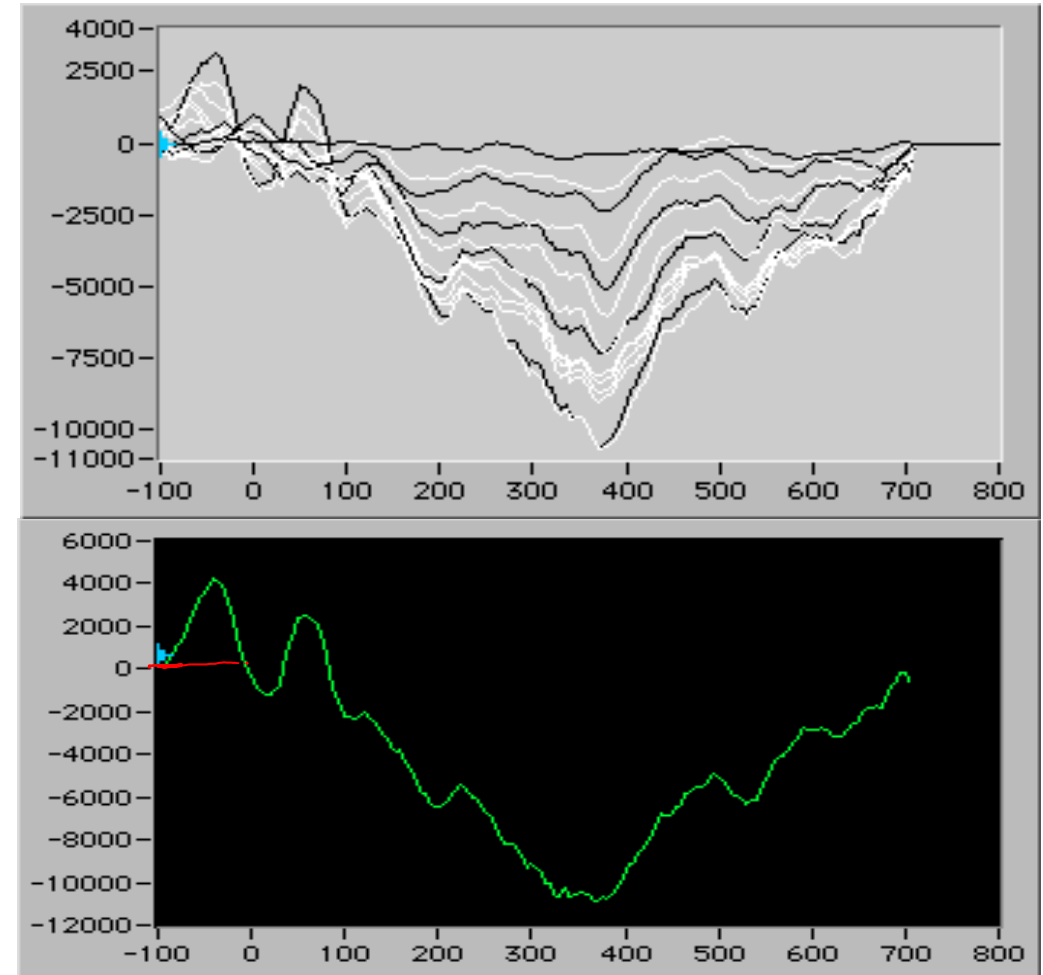
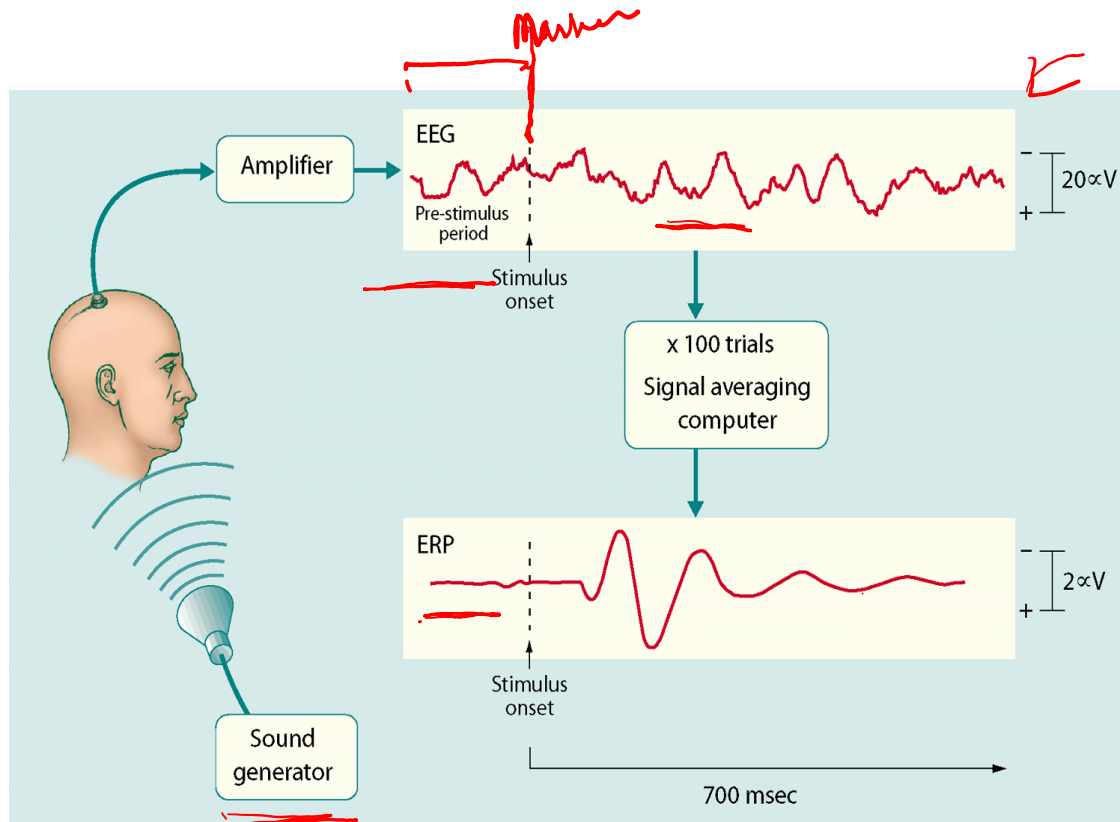
Categorization of EEG based BCI paradigms

ERD		Spontaneous
P300		Evoked
SSEP/AEP/VEP		Evoked
SCP		Spontaneous

Event Related Potentials (ERP)

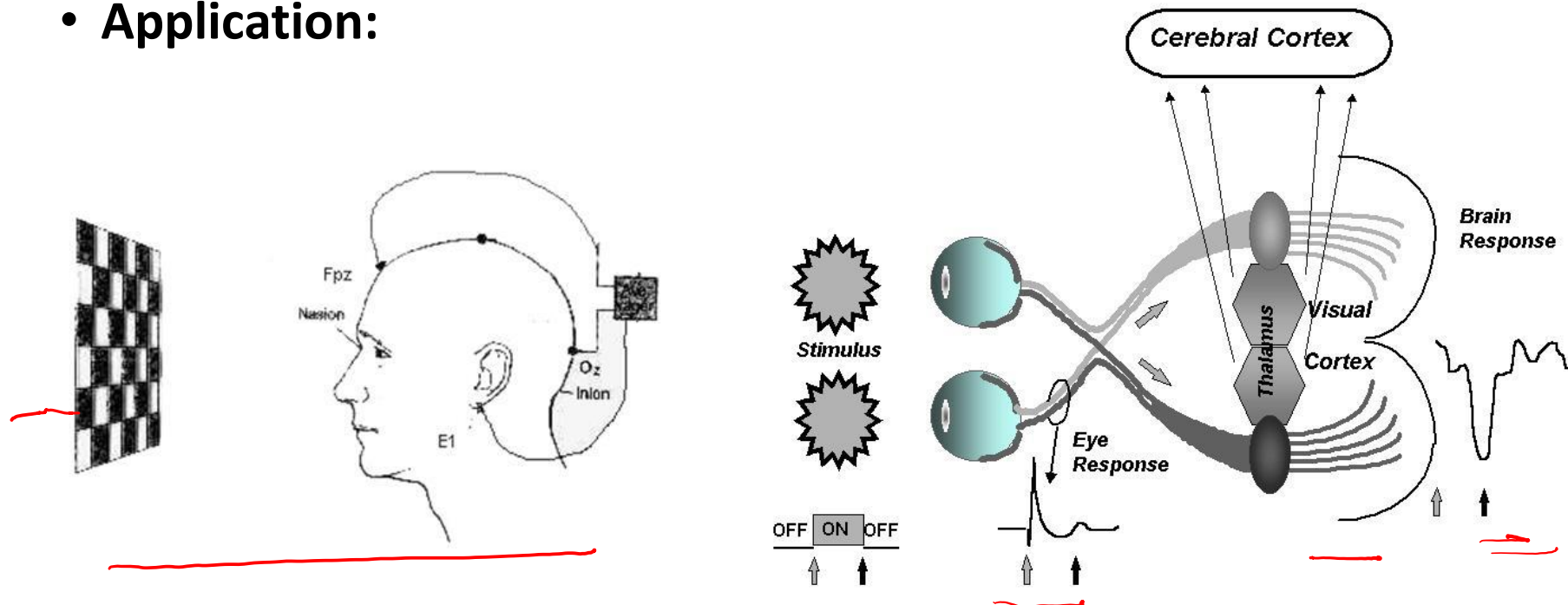
→ deflections → +ve P100
→ -ve N100

- Averaging of trials following a stimulus



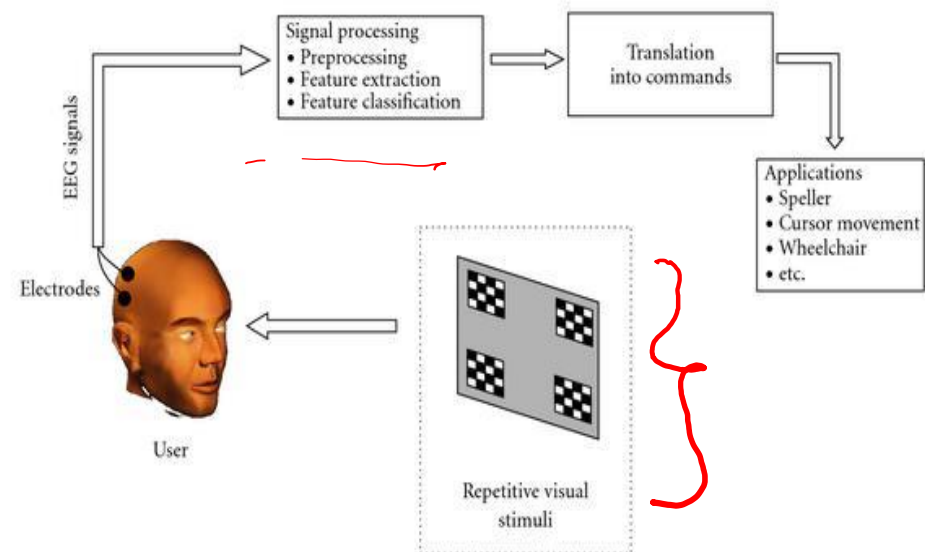
Visual Evoked Potential (VEP)

- Caused by Visual Stimulus
- Occurs with flashing lights (3-5 Hz)
- Have been used to monitor function during surgery for lesions involving the pituitary gland, optic nerve.
- Application:



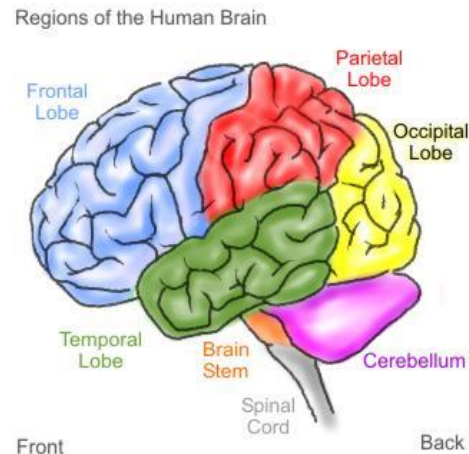
Steady-State Visual Evoked Potential (SSVEP)

- SSVEP are signals that are natural responses to visual stimulation at specific frequencies. When the retina is excited by a visual stimulus ranging from 3.5 Hz to 75 Hz, the brain generates electrical activity at the same (or multiples of) frequency of the visual stimulus.
- Excellent signal-to-noise ratio and relative immunity to artifacts.
- Applications:
 - SSVEP-controlled robots (Boston University)
 - User-friendly interface



P300 ← ERP

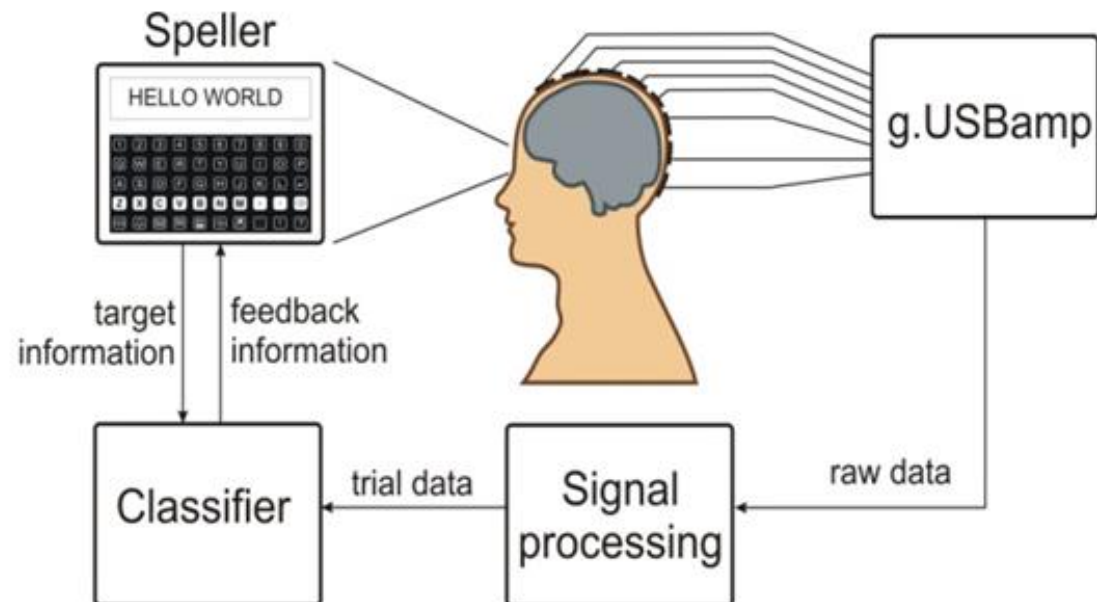
- P300 is thought to reflect processes involved in stimulus evaluation or categorization.
- It is usually elicited using the oddball paradigm in which low-probability target items are inter-mixed with high-probability non-target (or "standard") items.
- Results in a positive curve on EEG after 300ms.
- Strongest signal at parietal lobe.



- 6x6 matrix of symbols
- Subject concentrates on a symbol (i.e. cell)
- Each row and column flashes twice
 - i.e., 2 target flashes vs. 10 non-target flashes
 - random order
 - for very short time (e.g. 100 ms)

P300

- (Farwell and Donchin 1988)
- 95% accuracy at 1 character per 26s

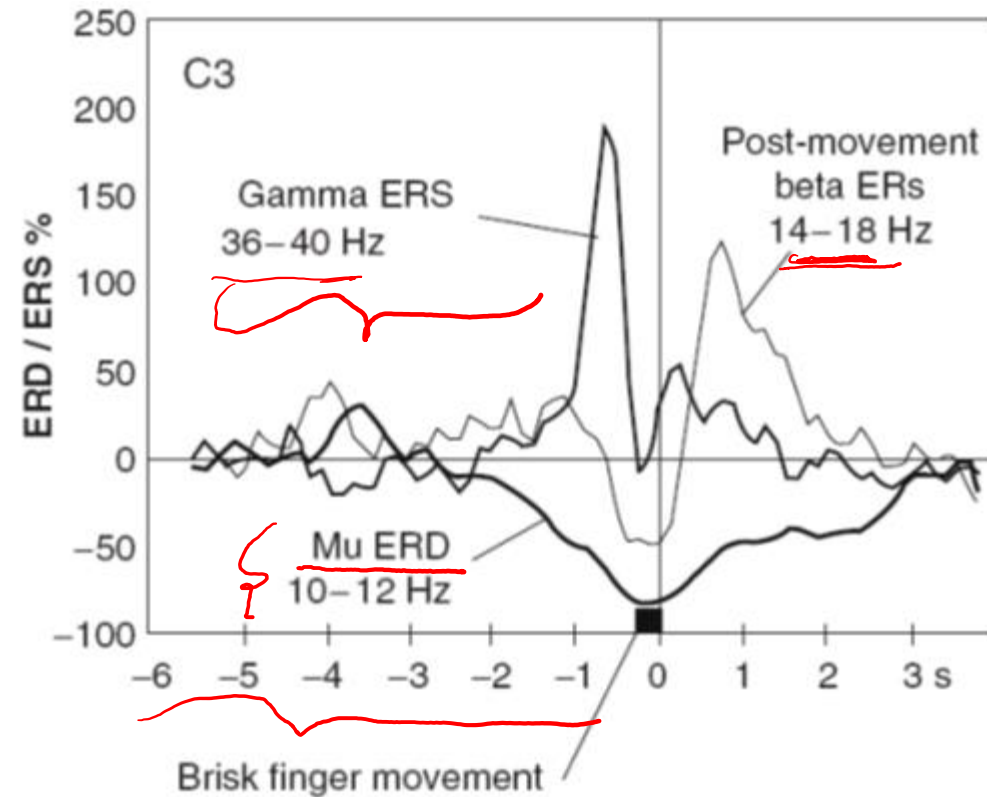


ERS/ERD

- **Event-related desynchronization (ERD) and event-related synchronization (ERS) is the change of signal's power occurring in a given band relative to a reference interval.**
- **People have naturally occurred brain rhythms over areas of the brain concerned with touch and movement. When people imagine moving, these brain rhythms first become weaker, then stronger. These two changes are called ERD and ERS, respectively.**
- **ERS**
 - oscillatory power increase
 - associated with activity decrease
- **ERD**
 - oscillatory power decrease
 - associated with activity increase

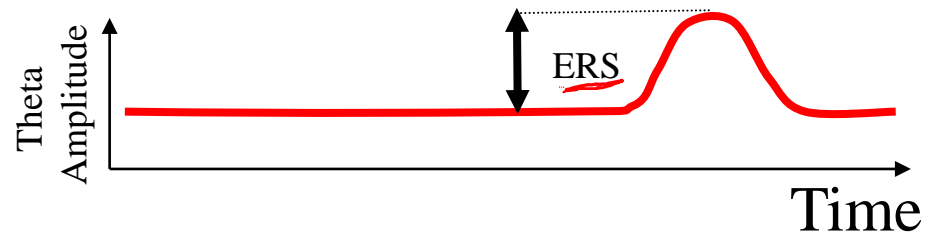
ERS/ERD

- The imagination of either a left or right hand movement results in:
 - An amplitude attenuation (Event-Related Desynchronization (ERD)) of μ (8-12Hz) and central beta EEG-rhythms (13-30Hz) at the contralateral sensorial motor representation area and,
 - in some cases, in an amplitude increase (Event-Related Synchronization (ERS)) within the γ -band (30-40Hz) at the ipsilateral hemisphere(6).



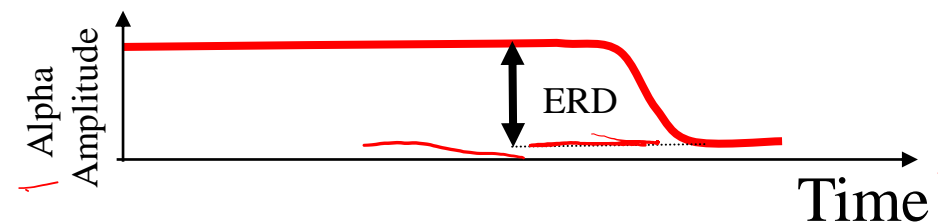
EEG recorded from C3 electrode.

4-8 Hz
8-13 Hz



Pre-Stimulus Post-Stimulus

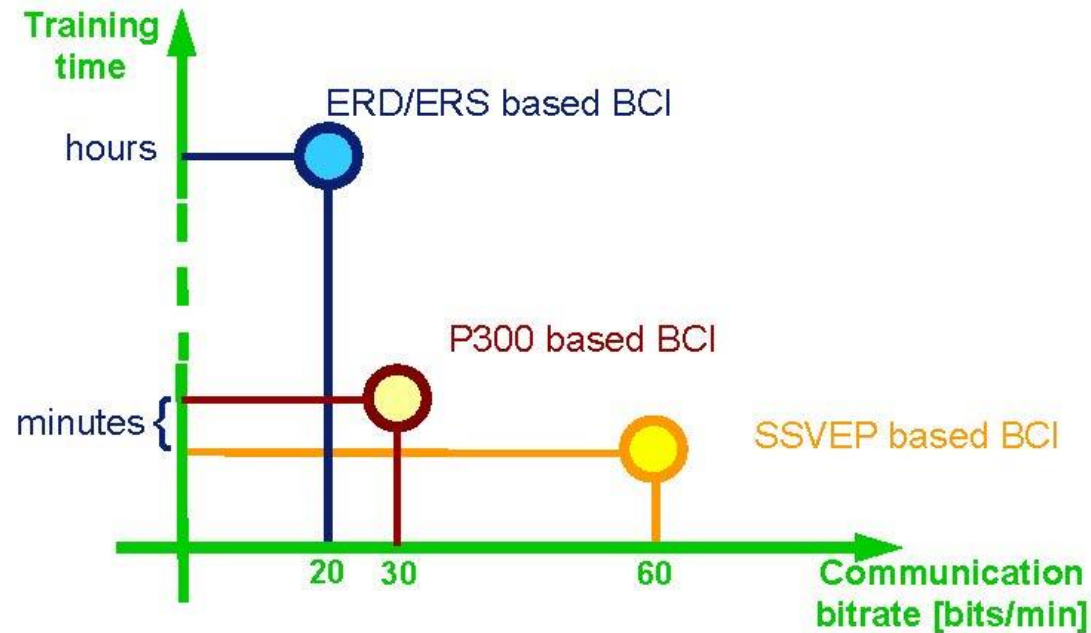
Stimulus



Pre-Stimulus Post-Stimulus

Stimulus

Communication Issues



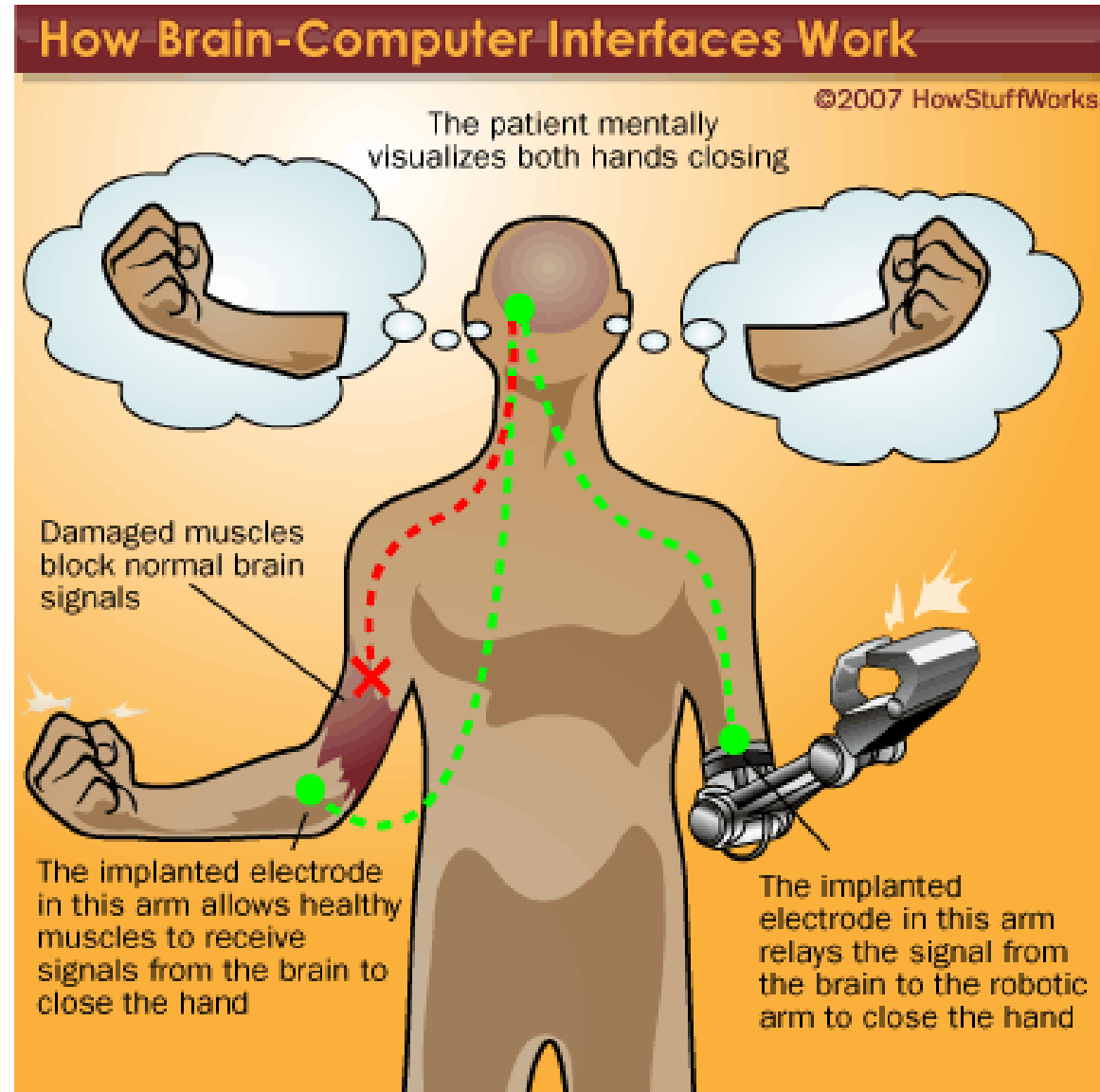
Typical training time versus communication bitrate for the three main types of noninvasive EEG based BCIs.

BCI Applications

BCI – operated robot



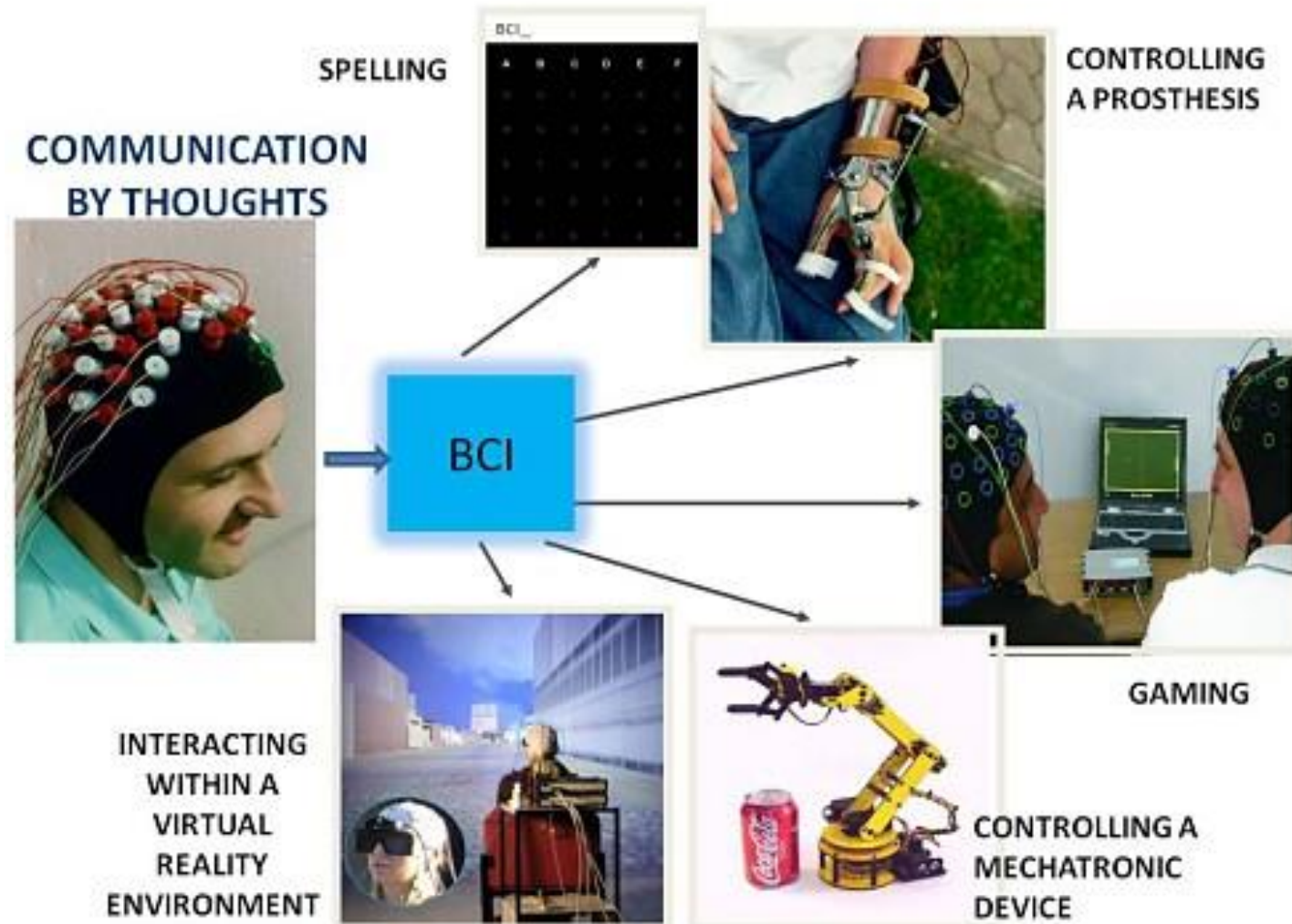
BCI Applications



BCI Applications



BCI Applications



Thank you!